AD-A091 245 ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND ABERD--ETC F/G 13/11
PRESSURE REGULATION IN A REDUCED PRESSURE CHAMBER USING A CRYOG--ETC(U)
AUG 80 M A DEWILDE
UNCLASSIFIED ARBRL-MR-03056 SBIE-AD-E430 519 NL

END
DATE
FILMED
12-80
DTIC

MEMORANDUM REPORT ARBRL-MR-03056

PRESSURE REGULATION IN A REDUCED PRESSURE CHAMBER USING A CRYOGENIC TEMPERATURE CONTROLLER

Mark A. Dewilde

August 1980

US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
BALLISTIC RESEARCH LABORATORY
ABERDEEN PROVING GROUND, MARYLAND

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: MEMORANDUM REPORT ARBRL-MR-03056	2. GOVT ACCESSION NO.: AD-A091245	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): PRESSURE REGULATION IN A REDUCED PRESSURE CHAMBER USING A CRYOGENIC TEMPERATURE CONTROLLER		5. TYPE OF REPORT & PERIOD COVERED: BRL Memorandum Report
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Mark A. Dewilde		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: USA Armament Research and Development Command, USA Ballistic Research Laboratory, ATTN: DRDAR-BLP, Aberdeen Proving Ground, MD 21005		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 1L161102AH43
11. CONTROLLING OFFICE NAME AND ADDRESS: USA Armament Research and Development Command, USA Ballistic Research Laboratory, ATTN: DRDAR-BL, Aberdeen Proving Ground, MD 21005		12. REPORT DATE: Aug 1980
		13. NUMBER OF PAGES: 20
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report): Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Pressure Regulator

20. ABSTRACT (Continue on reverse side if necessary and identify by block number) srf

A cryogenic temperature controller, invented at the University of Virginia, is adapted for use as a pressure regulator in a reduced pressure flame studies system. Designed for use in a dynamic flow system, the regulator will hold a pressure within worst limits of 5 mm Hg throughout a flow range of 0.1 ℓpm to 40 ℓpm, in a pressure range of 2 to 760 mm.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

Figure | Page

I. INTRODUCTION

In cryogenic studies, temperatures below 4.2°K are routinely required and are attained by reducing the pressure over a liquid helium bath. For temperature control, this pressure must be kept constant within a few mm Hg, at flow rates which vary with heat flow to the liquid helium bath. Our requirements for pressure regulation in a reduced pressure chamber containing a flat flame burner were similar, and with modifications, the regulator has been used to provide the required degree of precision.

In Figure 1, the major components of the regulator are shown. Gas from the system to be regulated enters the regulator at the connection on the left, passes through the regulator intake tip (1) into the tubular diaphragm (2) through the regulator outlet tip (3) and on to the vacuum pump (not shown) which must be able to maintain the desired pressure at the desired flow. The main flow of gas is not permitted to enter the regulator chamber (4), which is sealed with O-rings to the aluminum backplate (5) and the plexiglass faceplate (6). The flow of gas through the regulator is permitted only so long as the pressure inside the tubular diaphragm (2) exceeds the pressure in the regulator chamber (4) so that the diaphragm does not cover the holes in the exhaust regulator tip (3). When the pressure inside the diaphragm (2) is less than that in the regulator chamber, the diaphragm collapses and closes off the holes in the exhaust regulator tip (3). The regulator chamber pressure is reduced by briefly opening valve (7), and increased by opening valve (8).

The strict on-off action described above is not desirable for most applications, so the regulator tips (1) and (3) are tapered. When the diaphragm begins to collapse, it closes off more and more of the holes in the tip (3) providing a variable-area orifice to pump through, and thus, proportional control.

II. DESIGN STANDARDS

For flame gases, the spacing and the diameters of the regulator tip holes is different than that for helium gas, which has much lower viscosity and requires less aperture for proper operation. If the diameter of the holes are made too large, the diaphragm will be sucked into them and will rupture, or will be too tightly held for the gas to push away from the holes. The same holds true for the spacing of the holes. The angle of the taper also helps to determine the opening and closing pressures of the regulator. It is possible to calculate what the pressure on the diaphragm is at a given pressure difference, angle of taper and elastic constant of the diaphragm material, but such calculations serve only to give a starting point. For a given gas mixture, several sets of tips may have to be made in order to reach desired performance, each with different hole spacing and taper angle.

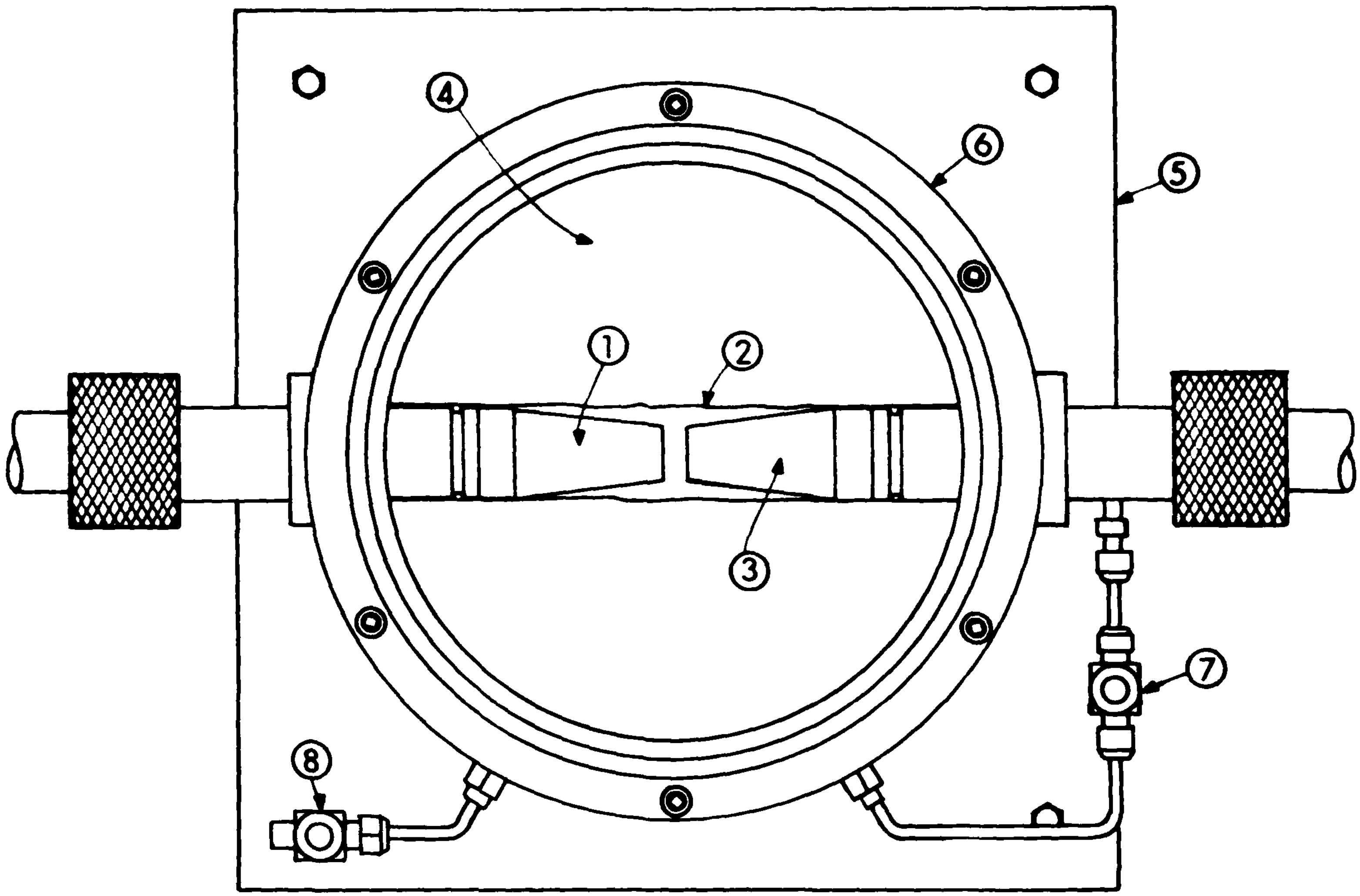

Figure 1. Regulator in TOTO

Ideally, the sum of the areas of the holes in a regulator tip should at least equal the area of the pipes bringing gas to and from the regulator.

III. DIMENSIONS AND CONSTRUCTION OF A REGULATOR FOR FLAME EXHAUST GASES

Figures 2 and 3 contain the dimensions of the pressure regulator couplings and gas channels. The couplings were designed for standard one inch (nominal) copper tubing. The material used was aluminum, although brass or stainless steel are equally suitable. Stainless steel is preferred for more corrosive gases. O-rings provide the seals between the coupling/gas channel pieces and the pressure regulator shell, Figure 4. Figure 5 shows the dimensions of the back and front plates for the pressure regulator shell. Figure 6 shows the pressure regulator tips. The holes are .025 inch in diameter and placed on the intersections of a .15 inch by .15 inch grid on the surface of the tips. The ends of the tips are closed by a press-fitted end cap.

The tubular diaphragm is perhaps the most elegant part of the design. For maximum flexibility, resiliency, and convenience, an ordinary condom, with the closed end cut-off, provides an excellent solution to the problem. Once the not totally unexpected reluctance and mirth of the procurement system can be overcome, the immediate availability and low cost proves to be a hidden advantage, since few elastomers can stand up to the corrosive gases produced by certain flames, and replacement can become necessary daily.

IV. CONCLUSION

Although this design is certainly not the only or best one for pressure regulation in the fraction-of-an-atmosphere domain, it certainly has advantages over cartesian-diver types of devices, both in cost and in absence of the hazardous mercury metal required by most. For the volumes of gas that this regulator will pass, most other devices of this sort are large and cumbersome, or lack the degree of precision that is available.

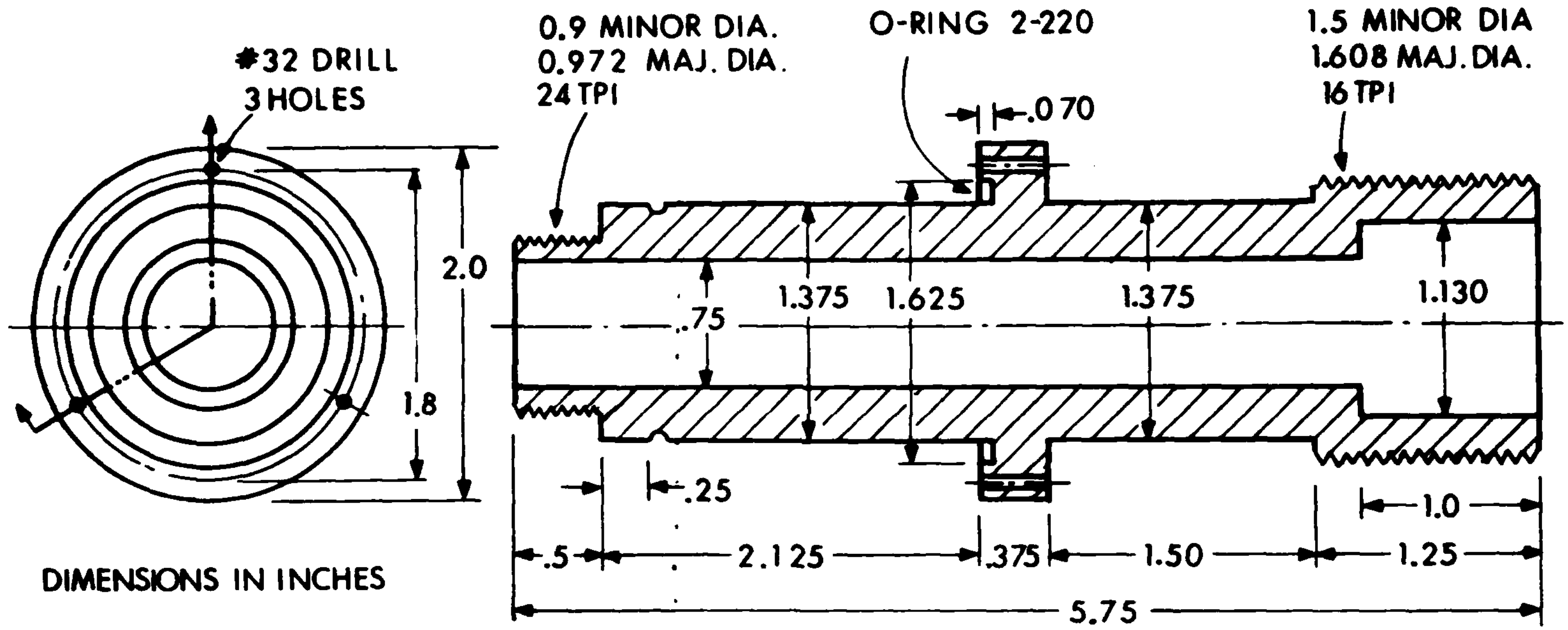

Figure 2. Gas Channel

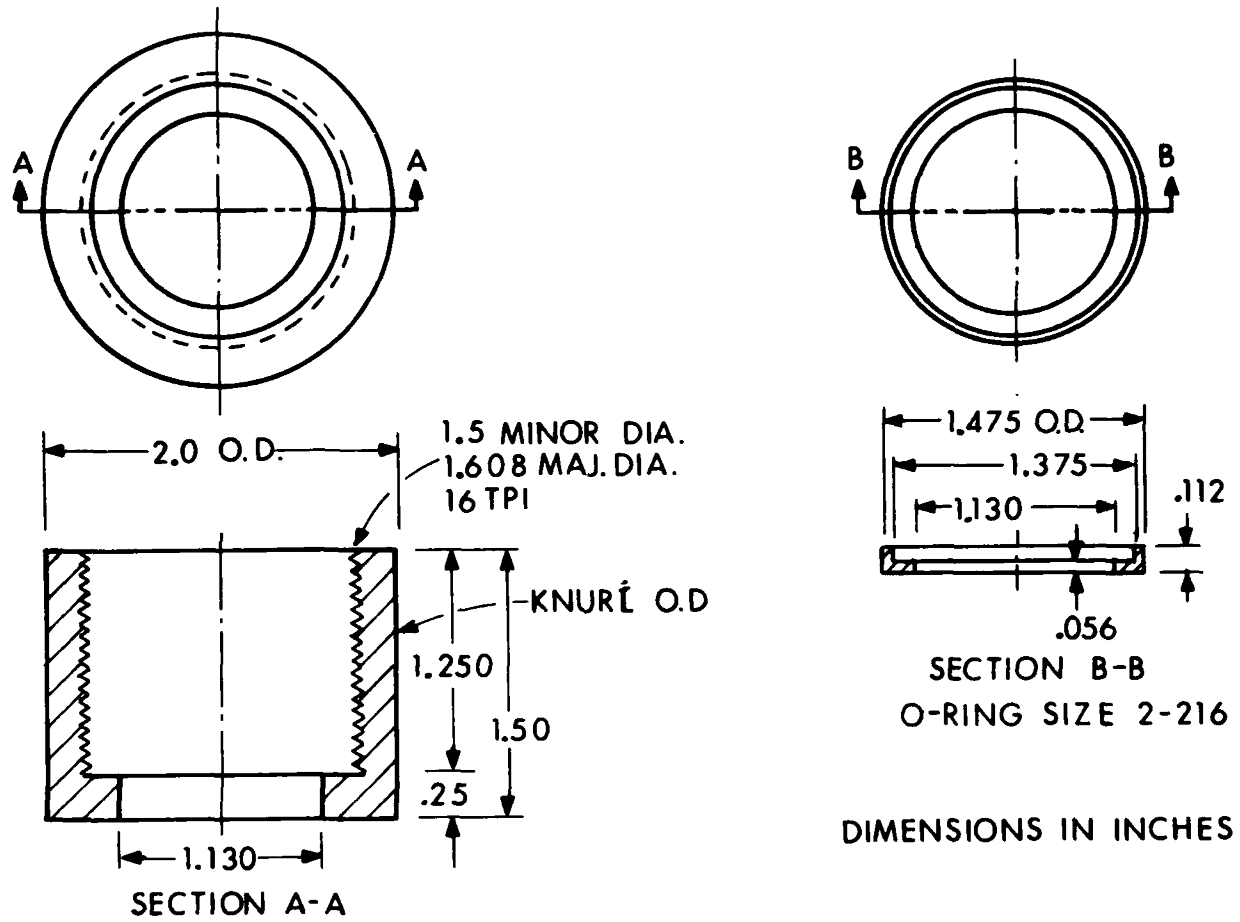

Figure 3. Coupling Nut and O-ring Retainer

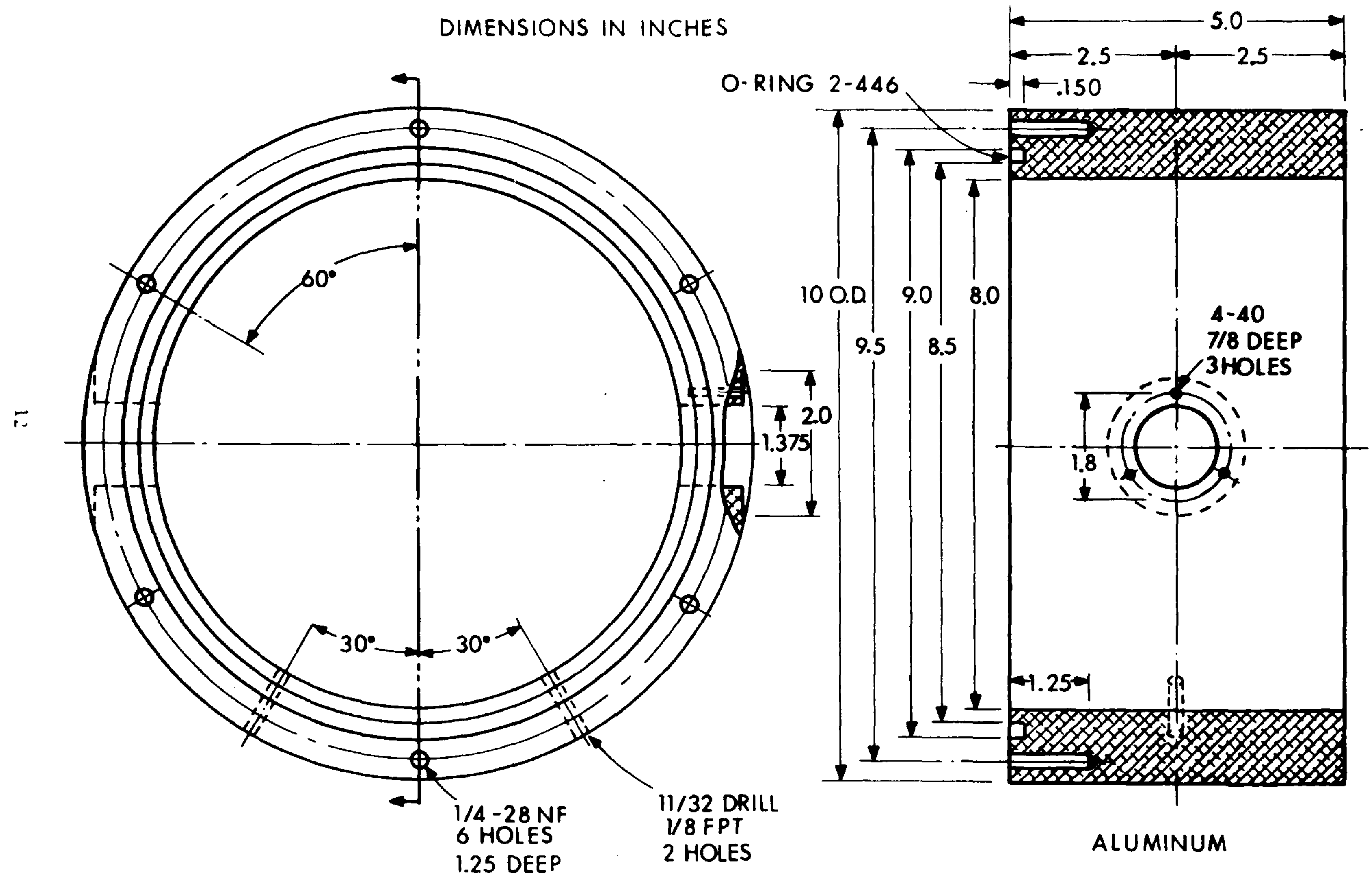

Figure 4. Chamber

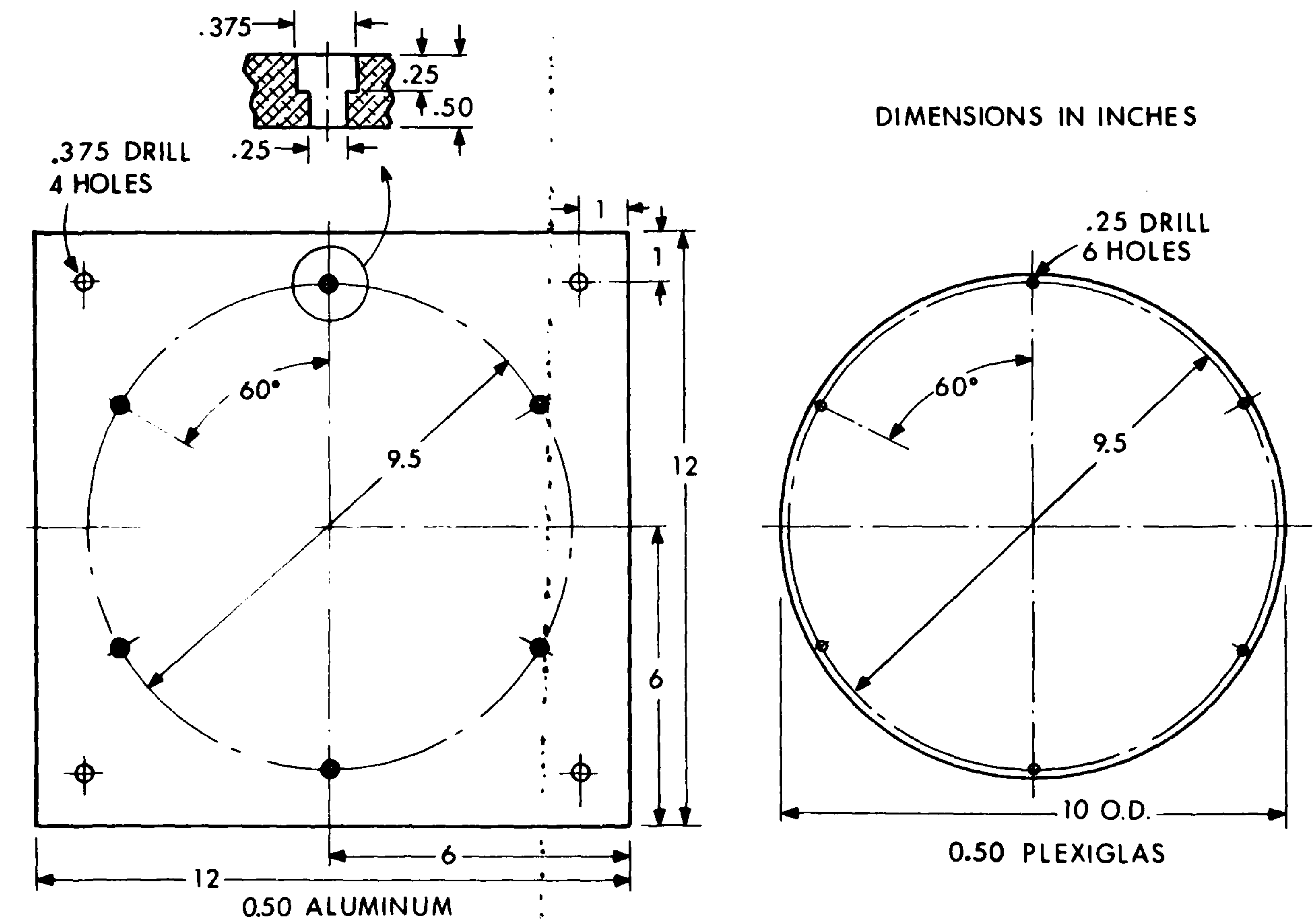

Figure 5. Front and Rear Chamber Cover Plates

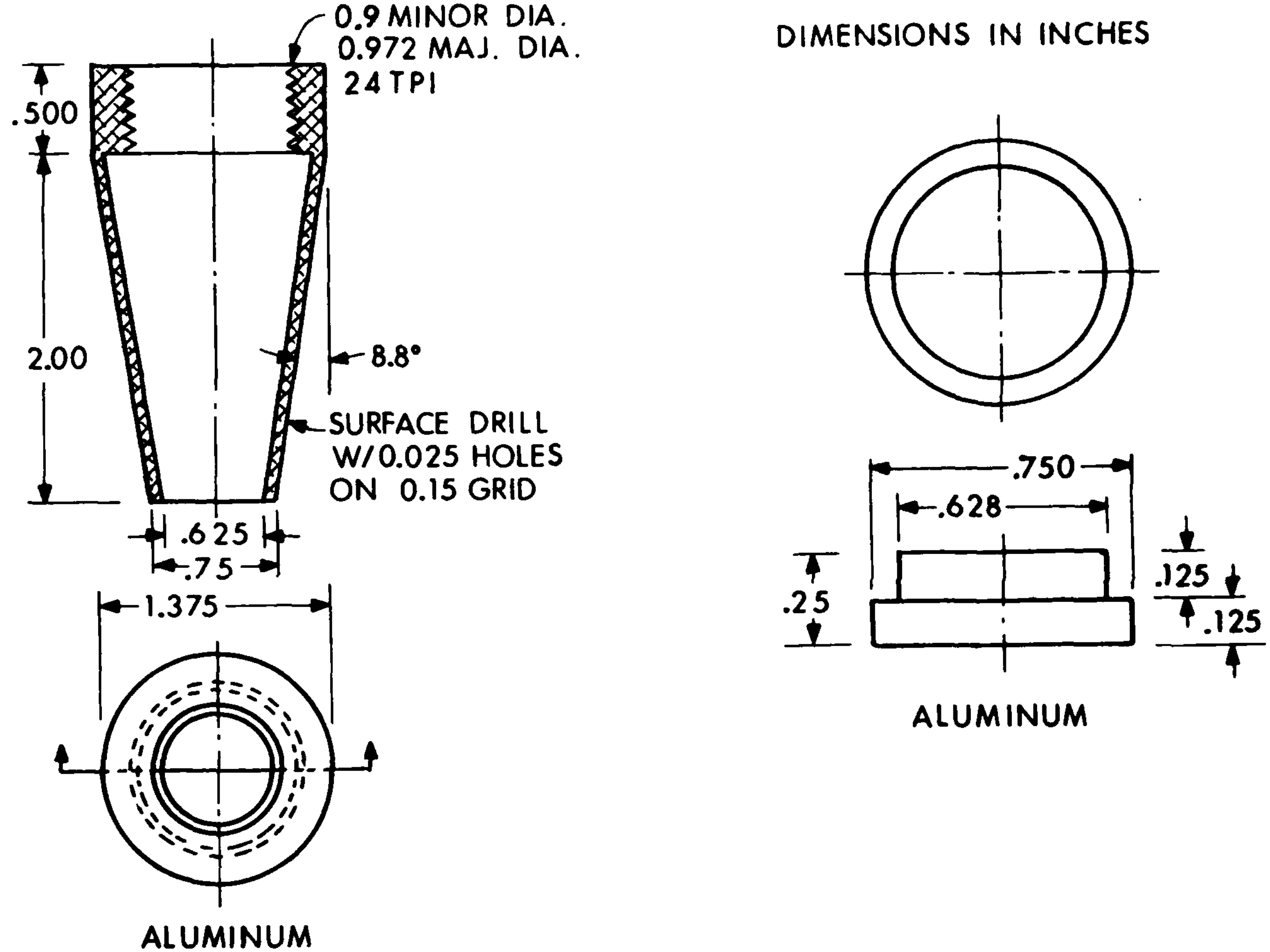

Figure 6. Tips and Related Parts

DISTRIBUTION LIST

No. of Copies	Organization
12	Commander Defense Technical Info Center ATTN: DDC-DDA Cameron Station Alexandria, VA 22314
1	Director Defense Advanced Research Projects Agency ATTN: LTC C. Buck 1400 Wilson Boulevard Arlington, VA 22209
2	Director Institute for Defense Analysis ATTN: H. Wolfhard R. T. Oliver 400 Army-Navy Drive Arlington, VA 22202
1	Commander US Army Materiel Development and Readiness Command ATTN: DRCDMD-ST 5001 Eisenhower Avenue Alexandria, VA 22333
2	Commander US Army Armament Research and Development Command ATTN: DRDAR-TSS Dover, NJ 07801
5	Commander US Army Armament Research and Development Command ATTN: DRDAR-LCA, J. Lannon DRDAR-LC, T.Vladimiroff DRDAR-LCE, F. Owens DRDAR-SCA, L. Stiefel DRDAR-LC, D. Downs Dover, NJ 07801
1	Commander US Army Armament Materiel Readiness Command ATTN: DRSAR-LEP-L, Tech Lib Rock Island, IL 61299
1	Director US Army ARRADCOM Benet Weapons Laboratory ATTN: DRDAR-LCB-TL Watervliet, NY 12189
1	Commander US Army Watervliet Arsenal ATTN: Code SARWV-RD, R.Thierry Watervliet, NY 12189
1	Commander US Army Aviation Research and Development Command ATTN: DRSAV-E P. O. Box 209 St. Louis, MO 63166
1	Director US Army Air Mobility Research and Development Laboratory Ames Research Center Moffett Field, CA 94035
1	Commander US Army Communications Rsch and Development Command ATTN: DRDCO-PPA-SA Fort Monmouth, NJ 07703
1	Commander US Army Electronics Research and Development Command Technical Support Activity ATTN: DELSD-L Fort Monmouth, NJ 07703

DISTRIBUTION LIST

No. of Copies	Organization
1	Commander US Army Missile Command ATTN: DRSMI-R Redstone Arsenal, AL 35809
1	Commander US Army Missile Command ATTN: DRSMI-YDL Redstone Arsenal, AL 35809
1	Commander US Army Natick Research and Development Command ATTN: DRXRE, D. Sieling Natick, MA 01762
1	Commander US Army Tank Automotive Research & Development Cmd ATTN: DRDTA-UL Warren, MI 48090
1	Commander US Army White Sands Missile Range ATTN: STEWS-VT White Sands, NM 88002
1	Commander US Army Materials and Mechanics Research Center ATTN: DRXMR-ATL Watertown, MA 02172
3	Commander US Army Research Office ATTN: Tech Lib D. Squire F. Schmiedeshaff R. Ghirardelli M. Ciftan P. O. Box 12211 Research Triangle Park NC 27706
1	Director US Army TRADOC Systems Analysis Activity ATTN: ATAA-SL, Tech Lib White Sands Missile Range NM 88002
2	Office of Naval Research ATTN: Code 473 G. Neece 800 N. Quincy Street Arlington, VA 22217
1	Commander Naval Sea Systems Command ATTN: J.W. Murrin, SEA-62R2 National Center Bldg. 2, Room 6E08 Washington, DC 20360
1	Commander Naval Surface Weapons Center ATTN: Library Br., DX-21 Dahlgren, VA 22448
2	Commander Naval Surface Weapons Center ATTN: S. J. Jacobs, Code 240 Code 730 Silver Spring, MD 20910
1	Commander Naval Underwater Systems Cmd Energy Conversion Department ATTN: R.S. Lazar, Code 5B331 Newport, RI 02840
2	Commander Naval Weapons Center ATTN: R. Derr C. Thelen China Lake, CA 93555

DISTRIBUTION LIST

No. of Copies	Organization
1	Commander Naval Research Laboratory ATTN: Code 6180 Washington, DC 20375
3	Superintendent Naval Postgraduate School ATTN: Tech Lib D. Netzer A. Fuhs Monterey, CA 93940
2	Commander Naval Ordnance Station ATTN: A. Roberts Tech Lib Indian Head, MD 20640
3	AFOSR (B.T. Wolfson; D. Ball; L. Caveny) Bolling AFB, DC 20332
2	AFRPL (DYSC) ATTN: D. George J. N. Levine Edwards AFB, CA 93523
2	National Bureau of Standards ATTN: J. Hastie T. Kashiwagi Washington, DC 20234
1	Lockheed Palo Alto Rsch Labs ATTN: Tech Info Ctr 3521 Hanover Street Palo Alto, CA 94304
1	Aerojet Solid Propulsion Co. ATTN: P. Micheli Sacramento, CA 95813
1	ARO Incorporated ATTN: N. Dougherty Arnold AFS, TN 37389

No. of Copies	Organization
1	Atlantic Research Corporation ATTN: M. K. King 5390 Cherokee Avenue Alexandria, VA 22314
1	AVCO Corporation AVCO Everett Research Lab Div ATTN: D. Stickler 2385 Revere Beach Parkway Everett, MA 02149
1	Foster Miller Associates, Inc. ATTN: A. J. Erickson 135 Second Avenue Waltham, MA 02154
1	General Electric Company Armament Department ATTN: M. J. Bulman Lakeside Avenue Burlington, VT 05402
1	General Electric Company Flight Propulsion Division ATTN: Tech Lib Cincinatti, OH 45215
2	Hercules Incorporated Alleghany Ballistic Lab ATTN: R. Miller Tech Lib Cumberland, MD 21501
1	Hercules Incorporated Bacchus Works ATTN: B. Isom Magna, UT 84044
1	IITRI ATTN: M. J. Klein 10 West 35th Street Chicago, IL 60615

DISTRIBUTION LIST

No. of Copies	Organization
1	Olin Corporation Badger Army Ammunition Plant ATTN: J. Ramnarace Baraboo, WI 53913
2	Olin Corporation New Haven Plant ATTN: R.L. Cook D.W. Riefler 275 Winchester Avenue New Haven, CT 06504
1	Paul Gough Associates, Inc. ATTN: P.S. Gough P. O. Box 1614 Portsmouth, NH 03801
1	Physics International Co. 2700 Merced Street Leandro, CA 94577
1	Pulsepower Systems, Inc. ATTN: L. C. Elmore 815 American Street San Carlos, CA 94070
3	Rockwell International Corp. Rocketdyne Division ATTN: C. Obert J. E. Flanagan A. Axeworthy 6633 Canoga Avenue Canoga Park, CA 91304
2	Rockwell International Corp. Rocketdyne Division ATTN: W. Haymes Tech Lib McGregor, TX 76657
1	Science Applications, Inc. ATTN: R. B. Edelman Combustion Dynamics and Propulsion Division 23146 Cumorah Crest Woodland Hills, CA 91364
1	Shock Hydrodynamics, Inc. ATTN: W. H. Anderson 4710-16 Vineland Avenue North Hollywood, CA 91602
1	Thiokol Corporation Elkton Division ATTN: E. Sutton Elkton, MD 21921
3	Thiokol Corporation Huntsville Division ATTN: D. Flanigan R. Glick Tech Lib Huntsville, AL 35807
2	Thiokol Corporation Wasatch Division ATTN: J. Peterson Tech Lib P. O. Box 524 Brigham City, UT 84302
1	TRW Systems Group ATTN: H. Korman One Space Park Redondo Beach, CA 90278
2	United Technology Center ATTN: R. Brown Tech Lib P. O. Box 358 Sunnyvale, CA 94088
1	Universal Propulsion Co. ATTN: H.J. McSpadden 1800 W. Deer Valley Road Phoenix, AZ 85027
11	Battelle Memorial Institute ATTN: Tech Lib R. Bartlett (10 cys) 505 King Avenue Columbus, OH 43201

DISTRIBUTION LIST

No. of Copies	Organization	No. of Copies	Organization
1	Brigham Young University Dept of Chemical Engineering ATTN: M. W. Beckstead Provo, UT 84601	1	Pennsylvania State University Dept of Mechanical Engineering ATTN: K. Kuo University Park, PA 16801
1	California Institute of Tech 204 Karmar Lab Mail Stop 301-46 ATTN: F.E.C. Culick 1201 E. California Street Pasadena, CA 91125	1	Pennsylvania State University Dept of Material Sciences ATTN: H. Palmer University Park, PA 16801
1	Case Western Reserve Univ. Division of Aerospace Sciences ATTN: J. Tien Cleveland, OH 44135	2	Princeton University Forrestal Campus ATTN: I. Glassman Tech Lib P. O. Box 710 Princeton, NJ 08540
3	Georgia Institute of Tech School of Aerospace Eng. ATTN: B. T. Zinn E. Price W.C. Strahle Atlanta, GA 30332	2	Purdue University School of Mechanical Eng ATTN: J. Osborn S.N.B. Murthy TSPC Chaffee Hall West Lafayette, IN 47906
1	Institute of Gas Technology ATTN: D. Gidaspow 3424 S. State Street Chicago, IL 60616	1	Rutgers State University Dept of Mechanical and Aerospace Engineering ATTN: S. Temkin University Heights Campus New Brunswick, NJ 08903
1	Johns Hopkins University/APL Chemical Propulsion Info Agency ATTN: T. Christian Johns Hopkins Road Laurel, MD 20810	4	SRI International ATTN: Tech Lib D. Crosley J. Barker D. Golden 333 Ravenswood Avenue Menlo Park, CA 94025
1	Massachusetts Inst of Tech Dept of Mechanical Engineering ATTN: T. Toong Cambridge, MA 02139	1	Stevens Institute of Tech Davidson Library ATTN: R. McAlevy, III Hoboken, NJ 07030
1	Pennsylvania State University Applied Research Lab ATTN: G. M. Faeth P. O. Box 30 State College, PA 16801		

DISTRIBUTION LIST

No. of Copies	Organization
1	University of California, San Diego Ames Department ATTN: F. Williams P. O. Box 109 La Jolla, CA 92037
1	University of Illinois Dept of Aeronautical Eng ATTN: H. Krier Transportation Bldg, Rm 105 Urbana, IL 61801
1	University of Minnesota Dept of Mechanical Eng. ATTN: E. Fletcher Minneapolis, MN 55455
1	University of Southern California Department of Chemistry ATTN: S. Benson Los Angeles, CA 90007
1	University of Texas Dept of Chemistry ATTN: W. Gardiner H. Schaefer Austin, TX 78712
2	University of Utah Dept of Chemical Engineering ATTN: A. Baer G. Flandro Salt Lake City, UT 84112

Aberdeen Proving Ground

Dir, USAMSAA
ATTN: DRXSY-D
DRXSY-MP, H. Cohen
Cdr, USATECOM
ATTN: DRSTE-TO-F
Dir, USA CSL, Bldg. E3516
ATTN: DRDAR-CLB-PA

USER EVALUATION OF REPORT

Please take a few minutes to answer the questions below; tear out this sheet and return it to Director, US Army Ballistic Research Laboratory, ARRADCOM, ATTN: DRDAR-TSB, Aberdeen Proving Ground, Maryland 21005. Your comments will provide us with information for improving future reports.

1. BRL Report Number ______________________________

2. Does this report satisfy a need? (Comment on purpose, related project, or other area of interest for which report will be used.)

____

____

____

3. How, specifically, is the report being used? (Information source, design data or procedure, management procedure, source of ideas, etc.) ______________________________

____

____

4. Has the information in this report led to any quantitative savings as far as man-hours/contract dollars saved, operating costs avoided, efficiencies achieved, etc.? If so, please elaborate.

____

____

5. General Comments (Indicate what you think should be changed to make this report and future reports of this type more responsive to your needs, more usable, improve readability, etc.) __________

____

____

____

6. If you would like to be contacted by the personnel who prepared this report to raise specific questions or discuss the topic, please fill in the following information.

Name: ______________________________

Telephone Number: ______________________________

Organization Address: ______________________________

____

____